

Direct Measurement of Antiferromagnetic Domain Fluctuations using Coherent Diffraction

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Understanding collective dynamics in the presence of disorder has been of long standing interest in magnets from iron to high temperature superconductors. Here we present the first direct measurements of fluctuations in the nanoscale spin- and charge-density wave superstructure associated with weakly pinned antiferromagnetic domains in elemental Chromium. The technique used is X-ray Photon Correlation Spectroscopy, where coherent x-ray diffraction produces a speckle pattern that serves as a “fingerprint” of a particular magnetic domain configuration. We measure the temporal evolution of the patterns, which corresponds to domain walls advancing and retreating over micron distances. While the domain wall motion is thermally activated at temperatures above 100K, it is not so at lower temperatures, and indeed has a rate which saturates at a finite value – consistent with quantum fluctuations - on cooling below 40K. We discuss a model in which the tunneling degree of freedom, which involves rotating the Fermi surface by 90 degrees, can be considered a spherical, nanoscopic ‘quantum’ rotor in a potential with minimum along the cubic directions. We will also show that the dynamics of magnetic domains in chromium is a special case of the more general class of problems of dynamics in disordered systems that include everything from glassy behavior and ‘jamming’ in gels to earthquakes. Unique to the antiferromagnetic system, however, is that quantum tunneling can provide an additional channel for relaxation.